Appendix C. NGSS: Applying Disciplinary Core Ideas (DCIs) in Outdoor Science

DCIs are conceptual science understandings that are important for students to know, and they might be described as, "what science knows." This handout is for helping activity designers make realistic and accurate connections to the Next Generation Science Standards (NGSS) DCIs. It includes a selection of life science, earth science, and engineering design DCIs that are closely related to concepts and experiences common in outdoor science programs that have the potential to be investigated through nature-centered activities. Left out here are DCIs that are certainly important but difficult to learn about through direct nature studies, and are probably best taught in a classroom. Outdoor science is at its best when it plays to the strength of learning through direct engagement with nature, not when it involves too many models and simulations of things students can't directly experience outdoors. That's why parts of the DCIs included here should be skipped, because they would be difficult to teach through direct engagement with nature, and should not be the focus of outdoor science. This appendix is not a comprehensive list of all DCIs, but is a list of DCI topics and ideas that might be useful for most outdoor science programs to think about to guide their instruction, and that might be possible to teach outdoors.

For more details about understanding the Disciplinary Core Ideas, see Chapter 6: Disciplinary Core Ideas—Life Sciences, Chapter 7: Disciplinary Core Ideas—Earth and Space Sciences, and Chapter 8: Engineering, Technology and Applications of Science in *A Framework for K-12 Science Education*. For information about specific grade-level performance expectations, see the NGSS, and look within the color-coded orange boxes for the DCIs associated with each grade-level performance expectation.

When choosing DCIs to focus on, it's important to recognize that these are complex ideas that can't be thoroughly taught and understood in one outdoor science experience, no matter how engaging it is! It's also important to be realistic in stating expectations for students —for instance, it shouldn't be claimed that your program can completely address all the ideas contained in a single DCI or a performance expectation.

For example, the BEETLES *Ecosystems, Matter and Energy Theme Hike* is a series of activities that can be used with 5th-grade students focused on developing some foundational understanding of the DCI: LS2.*A Interdependent Relationships in Ecosystems*, but it's not possible to completely address any DCI in one outdoor experience.
Note: This same hike also addresses parts of other DCIs, like LS2.B *Cycles of Matter and Energy Transfer in Ecosystems*. How do matter and energy move through an ecosystem?

Example of how a DCI can be addressed through a field experience.

LS2.A Interdependent Relationships in Ecosystems. How do organisms interact with the living and nonliving environments to obtain matter and energy?

By the end of grade 5:

The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Either way, they are "consumers." Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil for plants to use. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.

The hike begins with a *Walk & Talk* where students share ideas about connections between organisms, and they discuss systems in general. Then they explore and observe their surroundings using the *I Notice, I Wonder, It Reminds Me Of* routine. In the *What Lives Here?* activity they identify and record evidence of different plants, as well as other living and nonliving things in the ecosystem, making a model of the ecosystem that shows connections. They keep adding to this model throughout the hike. Next they explore a decomposing log to learn about other interdependent relationships and decomposition in *The Case of the Disappearing Log.* Then they discuss matter cycles and energy flow in the ecosystem using the *Food, Build, Do, Waste* activity. They use the ecosystem models they've been adding to throughout the hike to have a discussion about interdependence and how introducing new parts (like introduced species) or losing parts of the ecosystem affects the balance of the ecosystem. Finally, they reflect on what they've learned in a *Walk & Talk*.

This may seem like a lot of activities for teaching about one DCI, but this example shows how complex DCIs can be, and how you need a lot of time and extended experiences to address them with students—in this case a 6-hour long hike! And although the 6 activities in this theme hike can do a lot to develop middle school students' understanding of parts of this DCI, all of these parts can't be addressed in one experience! For a more complete understanding, students will need additional experiences with these concepts throughout their K-12 education. The role of your program and your site is to give them active outdoor learning experiences with some of these science concepts, that allow students to observe and think about real world examples in the context of working ecosystems.
This is why we recommend focusing on DCIs that are about processes or concepts students can actually observe directly (or observe the effects of) in the outdoors and at your site. The following is a list of DCIs that can have feasibly observed effects in the outdoors, and that might lead to interesting investigations through outdoor nature-centered, science experiences.

Life Science Core Ideas (text taken directly from *A Framework for K-12 Science Education,* Chapter 6)		
Core Idea LS1: From Molecules to Organisms: Structures and Processes. *How do organisms live, grow, respond to their environment and reproduce?*		
LS1.A: Structure and Function. *How do the structures of organisms enable life's functions?*		
By the end of grade 2: All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants.	*By the end of grade 5:* Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (Boundary: Stress at this grade level is on understanding the macroscale systems and their function, not microscopic processes.)	*Note: In grades 6–8 students are expected to learn about microscopic structures and processes and how they function in the cells of living organisms. LS1.A is not included for middle school here, because these kinds of investigations require special equipment and are not directly observable nor particularly nature-centered.*
LS1.B: Growth and Development of Organisms. *How do organisms grow and develop?*		
By the end of grade 2: Plants and animals have predictable characteristics at different stages of development. Plants and animals grow and change. Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.	*By the end of grade 5: Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles that include being born (sprouting in plants), growing, developing into adults, reproducing, and eventually dying.*	*By the end of grade 8:* Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. Animals engage in characteristic behaviors that increase the odds of reproduction. Plants reproduce in a variety of ways, sometimes depending on animal
LS1.C Organization for Matter and Energy Flow in Organisms. *How do organisms use the matter and energy they need to live and grow?*		

By the end of grade 2: All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.	*By the end of grade 5:* Animals and plants alike generally need to take in air and water, animals must take in food, and plants need light and minerals; anaerobic life, such as bacteria in the gut, functions without air. Food provides animals with the materials they need for body repair and growth and is digested to release the energy they need to maintain body warmth and for motion. Plants acquire their material for growth chiefly from air and water and process matter they have formed to maintain their internal conditions (e.g., at night)	*By the end of grade 8:* Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. Animals obtain food from eating plants or eating other animals. Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. In most animals and plants (also in fungi & aquatic organisms), oxygen reacts with carbon containing molecules (sugars) to provide energy and produce carbon dioxide; anaerobic bacteria achieve their energy needs in other chemical processes that do not require oxygen.
Core Idea LS2: Ecosystems: Interactions, Energy and Dynamics. *How and why do organisms interact with their environment and what are the effects of those interactions?*		
LS2.A Interdependent Relationships in Ecosystems. *How do organisms interact with the living and non-living environments to obtain matter and energy?*		
By the end of grade 2: Animals depend on their surroundings to get what they need, including food, water, shelter, and a favorable temperature. Animals depend on plants or other animals for food. They use their senses to find food and water, and they use their body parts to gather, catch, eat, and chew the food. Plants depend on air, water, minerals (in the soil), and light to grow. Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight.	*By the end of grade 5:* The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Either way, they are "consumers." Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil for plants to use. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.	*By the end of grade 8:* Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

LS2.B Cycles of Matter and Energy Transfer in Ecosystems. *How do matter and energy move through an ecosystem?*		
By the end of grade 2: Organisms obtain the materials they need to grow and survive from the environment. Many of these materials come from organisms and are used again by other organisms.	*By the end of grade 5:* Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, water, and minerals from the environment and release waste matter (gas, liquid, or solid) back into the environment.	*By the end of grade 8:* Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem. Transfers of matter into and out of the physical environment occur at every level—for example, when molecules from food react with oxygen captured from the environment, the carbon dioxide and water thus produced are transferred back to the environment, and ultimately so are waste products, such as fecal material. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms (matter) that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
LS2.C Ecosystem Dynamics, Functioning and Resilience. *What happens to ecosystems when the environment changes?*		
By the end of grade 2: The places where plants and animals live often change, sometimes slowly and sometimes rapidly. When animals and plants get too hot or too cold, they may die. If they cannot find enough food, water, or air, they may die.	*By the end of grade 5:* When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.	*By the end of grade 8:* Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.
LS2.D Social Interactions and Group Behavior. *How do organisms interact in groups so as to benefit individuals?*		
By the end of grade 2: Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size.	*By the end of grade 5:* Groups can be collections of equal individuals, hierarchies with dominant members, small families, groups of single or mixed gender, or groups composed of individuals similar in age. Some groups are stable over long periods of time; others are fluid, with members moving in and out. Some groups assign specialized tasks to each member; in others, all members perform the same or a similar range of functions.	*By the end of grade 8:* Groups may form because of genetic relatedness, physical proximity, or other recognition mechanisms (which may be species specific). They engage in a variety of signaling behaviors to maintain the group's integrity or to warn of threats. Groups often dissolve if they no longer function to meet individuals' needs, if dominant members lose their place, or if other key members are removed from the group through death, predation, or exclusion by other members.

Core Idea LS4: Biological Evolution: Unity and Diversity. *How can there be so many similarities among organisms yet so many different kinds of plants, animals and microorganisms? How does biodiversity affect humans?*		
LS4.B Natural Selection. *How does genetic variation among organisms affect survival and reproduction?*		
By the end of grade 2: (not addressed at this grade level)	*By the end of grade 5:* Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.	*By the end of grade 8:* Genetic variations among individuals in a population give some individuals an advantage in surviving and reproducing in their environment. This is known as natural selection. It leads to the predominance of certain traits in a population and the suppression of others. {In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed onto offspring.} *Note: This artificial selection is only observable if you have domesticated plants or animals at your site.*
LS4.C Adaptation. How does the environment *influence populations of organisms over multiple generations?*		
By the end of grade 2: Living things can survive only where their needs are met. If some places are too hot or too cold or have too little water or food, plants and animals may not be able to live there.	*By the end of grade 5:* Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.	*By the end of grade 8:* Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. {In separated populations with different conditions, the changes can be large enough that the populations, provided they remain separated (a process called reproductive isolation), evolve to become separate species.} *Note: The process of speciation is not easily observable though there may be evidence of its occurrence at your site.*
LS4.D Biodiversity and Humans. *What is biodiversity, how do humans affect it, and how does it affect humans?*		
By the end of grade 2: There are many different kinds of living things in any area, and they exist in different places on land and in water.	*By the end of grade 5:* Scientists have identified and classified many plants and animals. Populations of organisms live in a variety of habitats, and change in those habitats affects the organisms living there. Humans, like all other organisms, obtain living and nonliving resources from their environments.	*By the end of grade 8:* Biodiversity is the wide range of existing life forms that have adapted to the variety of conditions on Earth, from terrestrial to marine ecosystems. Biodiversity includes genetic variation within a species, in addition to species variation in different habitats and ecosystem types (e.g., forests, grasslands, wetlands). Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.

Earth and Space Science Core Ideas (text taken directly from *A Framework for K-12 Science Education,* Chapter 7)

Core Idea ESS1: Earth's Place in the Universe. *What is the universe, and what is Earth's place in it?*

ESS1.A: The Universe and its Stars. *What is the universe, and what goes on in stars?*

By the end of grade 2: Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. At night one can see the light coming from many stars with the naked eye, but telescopes make it possible to see many more and to observe them and the moon and planets in greater detail.	*By the end of grade 5:* The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth.	*By the end of grade 8:* Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. *Note: Understanding and explaining the motion of the Moon and planets in the solar system can be challenging for students (and adults) even with the use of models designed to help learners address misconceptions. See BEETLES Night Sky Activities.*

ESS1.B: Earth and the Solar System. *What are predictable patterns caused by Earth's movement in the solar system?*

By the end of grade 2: Seasonal patterns of sunrise and sunset can be observed, described, and predicted.	*By the end of grade 5:* The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily and seasonal changes in the length and direction of shadows; phases of the moon; and different positions of the sun, moon, and stars at different times of the day, month, and year. Some objects in the solar system can be seen with the naked eye. Planets in the night sky change positions and are not always visible from Earth as they orbit the sun. Stars appear in patterns called constellations, which can be used for navigation and appear to move together across the sky because of Earth's rotation.	*By the end of grade 8:* The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. *Note: Understanding and explaining the motion of the Moon and planets in the solar system, as well as the seasons, can be challenging for students (and adults) even with the use of models designed to help learners address misconceptions.*

Core Idea ESS2: Earth's Systems. *How and why is Earth constantly changing?*

ESS2.A: Earth Materials and Systems. *How do Earth's major systems interact?*

By the end of grade 2: Wind and water can change the shape of the land. The resulting landforms, together with the materials on the land, provide homes for living things.	*By the end of grade 5:* Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. Rainfall helps shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. Human activities affect Earth's systems and their interactions at its surface. *Note: Much of these core ideas are not directly observable, though some evidence of the processes described can be found.*	*By the end of grade 8:* All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. *Note: Much of these core ideas are not directly observable, though some evidence of the processes described can be found.*

ESS2.C: The Roles of Water in Earth's Surface Processes. *How do the properties and movements of water shape Earth's surface and affect its systems?*

By the end of grade 2: Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. It carries soil and rocks from one place to another and determines the variety of life forms that can live in a particular location.	*By the end of grade 5:* Water is found almost everywhere on Earth: as vapor; as fog or clouds in the atmosphere; as rain or snow falling from clouds; as ice, snow, and running water on land and in the ocean; and as groundwater beneath the surface. The downhill movement of water as it flows to the ocean shapes the appearance of the land. Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.	*By the end of grade 8:* Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation as well as downhill flows on land. The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. Global movements of water and its changes in form are propelled by sunlight and gravity. Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. *Note: Much of what is described in these water processes is fairly abstract, and having students memorize or chant the steps of the water cycle does not necessarily help to build understanding of what drives the process.*

ESS2.D: Weather and Climate. *What regulates weather and climate?*		
By the end of grade 2: Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.	*By the end of grade 5*: Weather is the minute-by-minute to day-by-day variation of the atmosphere's condition on a local scale. Scientists record the patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. Climate describes the ranges of an area's typical weather conditions and the extent to which those conditions vary over years to centuries.	*By the end of grade 8:* Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can be predicted only probabilistically. {The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable.} *Note: The effects of the ocean and atmosphere on weather and climate can be directly observed, but the explanations described here require the use of models and/or additional investigative experiences.*
ESS2.E: Biogeology. *How do living organisms alter Earth's processes and structures?*		
By the end of grade 2: Plants and animals (including humans) depend on the land, water, and air to live and grow. They in turn can change their environment (e.g., the shape of land, the flow of water).	*By the end of grade 5:* Living things affect the physical characteristics of their regions (e.g., plants' roots hold soil in place, beaver shelters and human-built dams alter the flow of water, plants' respiration affects the air). Many types of rocks and minerals are formed from the remains of organisms or are altered by their activities.	*Note: In grades 6–8 students are expected to learn about how changes in geology have influenced evolution of life on Earth. These kinds of investigations require an understanding of deep time and are not directly observable nor particularly nature-centered.*
Core Idea ESS3: Earth and Human Activity. *How do Earth's surface processes and human activities affect each other?*		
ESS3.A: Natural Resources. How do humans depend on Earth's resources?		
By the end of grade 2: Living things need water, air, and resources from the land, and they try to live in places that have the things they need. Humans use natural resources for everything they do: for example, they use soil and water to grow food, wood to burn to provide heat or to build shelters, and materials such as iron or copper extracted from Earth to make cooking pans.	*By the end of grade 5:* All materials, energy, and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.	*By the end of grade 8:* Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geological processes (link to ESS2.B). Renewable energy resources, and the technologies to exploit them, are being rapidly developed.

ESS3.C: Human Impacts on Earth Systems. *How do humans change the planet?*		
By the end of grade 2: Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things—for example, by reducing trash through reuse and recycling.	*By the end of grade 5:* Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. For example, they are treating sewage, reducing the amounts of materials they use, and regulating sources of pollution such as emissions from factories and power plants or the runoff from agricultural activities.	*By the end of grade 8:* Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
ESS3.D: Global Climate Change. *How do people model and predict the effects of human activities on Earth's climate?*		
	By the end of grade 5: If Earth's global mean temperature continues to rise, the lives of humans and other organisms will be affected in many different ways.	*By the end of grade 8:* Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

Engineering, Technology and the Applications of Science Core Ideas
(text taken directly from *A Framework for K-12 Science Education,* Chapter 8)

Note: Solving environmental issues can be considered an engineering design problem. Providing students with some of experiences described in this core idea, and discussing how the process can be applied to addressing problems and creating solutions, can help students to see that engineering is not just about building things.

Core Idea ETS1: Engineering Design. *zzz*

ETS1.A: Defining and Delimiting an Engineering Problem. *What are the criteria and constraints of a successful solution?*		
By the end of grade 2: A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.	*By the end of grade 5:* Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	*By the end of grade 8:* The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (e.g., familiarity with the local climate may rule out certain plants for the school garden).

ETS1.B: Developing Possible Solutions. What is the process for developing potential design solutions?		
By the end of grade 2: Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. To design something complicated, one may need to break the problem into parts and attend to each part separately but must then bring the parts together to test the overall plan.	By the end of grade 5: Research on a problem should be carried out—for example, through Internet searches, market research, or field observations—before beginning to design a solution. An often productive way to generate ideas is for people to work together to brainstorm, test, and refine possible solutions. Testing a solution involves investigating how well it performs under a range of likely conditions. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. There are many types of models, ranging from simple physical models to computer models. They can be used to investigate how a design might work, communicate the design to others, and compare different designs.	By the end of grade 8: A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be able to communicate and explain solutions to others. Models of all kinds are important for testing solutions, and computers are a valuable tool for simulating systems. Simulations are useful for predicting what would happen if various parameters of the model were changed, as well as for making improvements to the model based on peer and leader (e.g., teacher) feedback.